FOREST COVER CHANGE IN PENINSULAR MALAYSIA USING SATELLITE REMOTE SENSING DATA

NAZARIN EZZATY BINTI MOHD NAJIB

UNIVERSITI TEKNOLOGI MALAYSIA

FOREST COVER CHANGE IN PENINSULAR MALAYSIA USING SATELLITE REMOTE SENSING DATA

NAZARIN EZZATY BINTI MOHD NAJIB

A thesis submitted in partial fulfillment of the requirements for the award of the Master of Science (Remote Sensing)

Faculty of Geoinformation and Real Estate
Universiti Teknologi Malaysia

2015

DEDICATION

Million Thanks and Praise to Allah,
for giving me better life and this gold opputurnity.
I would like to dedicate this thesis for somebody that always be my priority in my life forever especially to:

My beloved and lovely mom (Pn Suzanah binti Sulaiman) & My beloved and great father (En Mohd Najib bin Sabri)

"Your heart is too big to be treated small, Your love is too precious to let go,
You are the MAGIC of my life"

AKNOWLEDGEMENTS

In the name of Allah, Most Gracious and Merciful, and peace and blessings be upon the Prophet Muhammad, praise and gratitude for giving strength and guidance in order to carry out this study.

First of all, I would like to express my ultimate appreciation with great honor to my master project supervisor, Assoc Prof. Dr Kasturi devi Kanniah of all the guidelines, guidance, advice, and brilliant opinion given to do this research.

Special thanks also to Malaysian Agricultural Department and forestry Department for providing forest cover data to complete this thesis. I also owe my deepest gratitude to Mr Tan Kian Pang and Lecturers of Universiti Teknologi Malaysia whose always share their knowledge at any time.

This appreciation also goes to all the technicians of FGHT (En Mat, En Aman, En Sharin, Sarah and Sofia).

With full of love not to forget my dearest and precious friend Fateen Nabilla binti Rasli, who always be there during hard and sweet moment of my life. To Nurul Amalin Fatihah,Hafsat, Mel, Noji and Nana, thanks for everything. Last but not least special thanks to my mentor my grandfather ~"Tokcu".

ABSTRACT

Forest balance the global ecosystem by maintaining sustainable interaction between living and non living things. Deforestation caused land to be fragile, and destroyed water catchment area. Soil will absorb large amount of water and eroded. The water that caught by the forest before flows unhindered to the river with the soil and cause extreme flood. Thus forest change should be monitored to maintain sustainable ecosystem. Sustainable forest management should be done to maintain future forest resources . Forest replantation have been done by forestry department. However, it is not sufficient to balance the ecosystem. Malaysia forest loss has been increased and recorded high rate of deforestation. Thus, continuous forest monitoring should be done.Remote sensing technology with the multispectral image that has high spatial, temporal, and radiometric resolution, possible to monitor the forest cover change in short period of time. The aim of this study is to investigate the forest cover change in Malaysia between 1990 and 2010 using Landsat and ALOS Palsar satellite images. CLASlite software used Landsat data, while ALOS Palsar use threshold to classify forest. Besides, comparison of forest cover from Support Vector Machine and Maximum Likelihood Classifier is carried out. Then the result is validated with Forestry Department statistics. Comparison of total forest cover from CLASlite, ALOS Palsar, land use map and forestry statistics also was being made. The change of forest is detected by selecting Iskandar and Kuala Lumpur area .CLAlite also show the deforestation and disturbance area in Peninsular Malaysia. Results show that a forest loss value is high, compare to forest gain value. Iskandar have forest loss about 54 966 hectare and gain 21 411 hectare, while Kuala Lumpur loss about 2 521 hectare and gain 3 004 hectare of forest. The result of this study will be useful for Forestry Department to monitor the deforestation in Malaysia.

ABSTRAK

Hutan penting dalam menyeimbangi ekosistem global dengan mengekalkan hubungan antara benda yang bernyawa dan tidak bernyawa. Penebangan hutan menyebabkan tanah menjadi rapuh, dan menghapuskan kawasan tadahan air. Tanah menyerap sebilangan besar air lalu terhakis. Air yang dahulunya diserap oleh hutan mengalir terus kedalam sungai bersama tanah dan mengakibatkan banjir. Maka, perubahan hutan harus dipantau agar dapat mengekalkan keseimbangan ekosistem.Pengurusan hutan yang mampan harus dilaksanakan supaya dapat mengekalkan sumber hutan pada masa akan datang. Penanaman semula hutan telah dijalankan oleh jabatan perhhutanan. Namun, tindakan ini tidak mencukupi bagi menyeimbangi kestabilan ekosistem. .Kehilangan kawasan hutan di Malaysia semakin meningkat dan menunjukkan kadar penebangan hutan yang tinggi. Maka pemantauan hutan secara berterusan harus dilaksanakan. Teknologi remote sensing dengan imej "*multispectral"* yang mempunyai resolusi "*spatial","temporal"*dan"*radiometric*" yang tinggi, ia berupaya memantau perubahan kawasan litupan hutan dalam tempoh yang singkat. Matlamat kajian adalah untuk mengkaji perubahan kawasan hutan di Malaysia diantara tahun 1990 sehingga tahun 2010dengan menggunakan imej satellite Landsat dan ALOS Palsar. Bagi menganalisa perubahan, kawasan hutan perlu dikenal pasti. Perisian CLASlite menggunakan data Landsat manakala data ALOS menggunakan "threshold" bagi mengenalpasti kawasan hutan. Perbandingan kawsan hutan dari "Support Vector Machine"dan "Maximum Likelihood Classifier" dijalankan. Hasil kajian disahkan dengan statistik hutan dari Jabatan Perhutanan Malaysia. Jumlah kawasan hutan dari CLASlite, ALOS Palsar, peta guna tanah and forestry statistics juga dijalankan.Perubahan hutan dikenalpasti dengan memilih Iskandar dan Kuala Lumpur sebagai kawasan yang kurang dilitupi awan. CLASlite juga menunjukkan kawasan penebangan dan pengurangan hutan. Hasil kajian menunjukkan perbezaan ketara antara kehilangan hutan dan pertambahan hutan. Jumlah kehilangan hutan di Iskandar sebanyak 54 966 hektar dan peningkatan kawasan hutan sebanyak 21 411 hektar, manakala Kuala Lumpur kehilangan kawsan hutan sebanyak 2 521 hektar dan meningkat 3 004 hektar. Hasil kajian akan membantu pihak Jabatan Perhutanan bagi memantau penebangan hutan di Malaysia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREAVIATIONS

ALOS	-	Advanced Land Observation Satellite
AVHRR	-	Advanced Very High Resolution Radiometer
CLASlite	-	Carnegie Landsat Analysis System Lite
CVA	-	Change Vector Analysis
EIA	-	Environmental Impact Assessment
FAO	-	Food and Agricultural Organisation
FCM	-	Fuzzy C-Means clustering
FRA	-	Forest Resource Assessment
GloVis	-	Global Visualization Viewer
HCVF	-	The High Conservation Value Forest
JAXA	-	Japan Aerospace Exploration Agency
JUPEM	-	Jabatan Ukur dan Pemetaan Malaysia
LIDAR	-	Light Detection and Ranging
MODIS	-	Moderate Resolution Imaging Spectroradiometer
MTIB	-	Malaysian Timber Industry Board
NATIP	-	National Timber Industry Policy 2009
NDVI	-	Normalized Difference Vegetation Index
NPV	-	Non Photosynthetic Vegetation
NRE	-	Natural Resources & Environment
PALSAR	-	Phased Array type L-band Synthetic Aperture Radar
PV	-	Photosynthetic Vegetation
SPOT	-	Satellite Probatoire d'Observation de la Terre
SVM	-	Support Vector Machines
TM	-	Thematic Mapper
ICUN	-	International Union for Conservation of Nature
USGS	-	U.S. Geological Survey
WWF	-	World Wide Federation

CHAPTER 1

INTRODUCTION

1.0 Introduction

Forest is a vital source of life. It holds millions of interactions between living and non living things. Almost all countries in this world have a forest cover. The critical issue that relates to forest nowadays is deforestation. Deforestation has been widely done from day to day (http://environment.nationalgeographic.com/). This chapter will explain about the current situation of forest and the study that will be carried out to detect the forest changes.

1.1 Background Study

Malaysia is a country that has a high percentage of tropical rain forest cover which is 84.46 percent (http://www.forestry.gov.my/). Location of Malaysia in the humid tropics awarded the country's environment with unique species of animals and plants. Tropical rainforest evolved millions of years ago and has its own ecosystem. Various ranges of organism share forest as their habitat from tiny microscopic organisms and fungus to the larger organisms (http://www.forestry.gov.my/). Records from forestry website showed that tropical rainforest contains habitat of 17,631 species of flora. In the category of flora, it includes 1,387 Briofit, 1,600 Ferns, 377 Algae, and its families, 4,180 Monocotyledons, 10,026 Dicotyledons and 61 Gymnosperms. While there are 9,563 species of animals that consist of birds, reptiles, mammals, amphibians, freshwater fishes, moth and butterflies and leaves beetles (http://www.forestry.gov.my/).

Because of the richness of Malaysian forest, it is important to have a sustainable ecosystem. The interaction of the forest with the other creatures will provide a lot of benefits to the forest itself. Forest provides habitat for the flora and fauna, while flora and fauna provide nutrient for the forest. Forests also are vital to human welfare. They help in controlling the flow of water and maintaining water regulation quality, controls flood, pollination, soil conservation, nutrient and a part of hydrological cycling (UNEP, 2010). The tropics have a loss of forest each year with 2101 square kilometers per year (Hansen et al., 2013). Malaysian forest contributes a large amount of profit for timber industry, which increases the income for the economic sector. National Timber Industry Policy stated that in 2008, estimated total merchandise exports of timber products contributed RM22.5 billion to Malaysia's economy. Besides, timber economy has provided employment for about 300,000 workers (NATIP, 2009). Thus the timber

product is an important source for Malaysian economy and more activity of logging will be carried out for timber supply.

The High Conservation Value Forest (HCVF) Toolkit for Malaysia aims to provide an outline for forest managers and other stakeholders to identify, manage, and monitor the forest cover (WWF, 2009). HCVF Toolkit is part of a series of toolkits that were developed under the WWF and IKEA Co-operation. HCVF Toolkit provides a practical method to identify or define High Conservation Values of forest which it can be used at a national or regional level (Jennings et al., 2003). High Conservation Value Forests mean that forest area needs to be properly managed in order to maintain or enhance the value**.** In order to develop appropriate forest management globally, forest identification is the most important thing to be done (Jennings et al, 2003).

Several toolkits have been developed which are Watershed Protection, Erosion Control and Barriers to Destructive Fire. The HCVF toolkits concept was initially developed to be used in forest management certification and first published in 1999 (Jennings et al, 2003). Changes in forest cover in terms of deforestation or forest cover area loss will affect the delivery of important ecosystem services. For example diversity of biodiversity, climate cycle, carbon content, and water control (Hansen et al., 2013). Forest influences the climate change by consuming carbon dioxide in their photosynthesis process. Carbon dioxide (CO2) is a key of greenhouse gases that cause the increase the global temperature. Deforestation changes the global carbon cycle and affects the atmospheric concentration of CO2 (FAO, 2013). Landsat data global analysis, was done to improve the knowledge of global forest scope and change by gathering information of gain and loss of forest by using existing Landsat spatial resolution (Hansen et al., 2013). Forest loss was defined as tree cover canopy that is totally removed at the Landsat pixel scale (Hansen et al., 2013). Remote sensing

techniques are used to ease the collection of multispectral, multiresolution, and multitemporal data. They can be extracted into useful information and sources, in order to understand and monitor land cover changes, especially to study large area. In this case, it shows that remote sensing is very important in detecting forest change. Change detection is defined as identifying differences of object state at the same location, but in a different time (Singh, 1989).

Identification of Earth's surface features changes in a good manners provides a better understanding about the relationship between human and natural phenomena. Thus rightful action can be taken to provide better management and use resources. Multi-temporal datasets are very crucial data needed for change detection. It has been used to analyse the changes of temporal effects on the Earth surface. Because of repetitive data acquisition, remotely sensed data is very suitable for use in forest monitoring. For example, Thematic Mapper (TM), Satellite Probatoire d'Observation de la Terre (SPOT), radar and Advanced Very High Resolution Radiometer (AVHRR). Various change detection applications by researchers have used these data to implement in their studies (Lu et al., 2004). Therefore, remotely sensed data is very useful in order to detect the forest cover change in Malaysia and maintain the sustainable biodiversity of forest and prevent forest loss.

1.2 Problem Statement

Forest change includes gain and loss of forest area. Brazil that has high records of deforestation was defeated by increasing forest loss in Indonesia, Malaysia, Paraguay, Bolivia, Zambia, Angola, and elsewhere. This shows that Malaysia's forest is facing a big problem (Hansen et al., 2013). Malaysia is the world's largest exporter of tropical forest resources , making timber the primary forest product in Malaysia (FDPM, 2000). In that case, it is one of the major reasons for the decrease in the number of forests in Malaysia from 1987 to 2006.

Figure 1.1 shows the Principal Statistics of Forestry and Logging, from 1987 to 2006 in Malaysia. In 1987, the forest cover was very high and the production of logs was lower than the forest cover. But the high value of forest area did not last long as it kept decreasing as the log production became higher. The highest log production was in the year 1992. While the forest area kept decreasing, log production became slower, but still higher than the forest area until the year 1998. This might be due to the action of controlling the log production by the Forestry Department in order to preserve the forest. Thus, it shows positive changes in forest area for the next year. Because of the increasing number of forest cover, the log production started to increase again until the year 2000. Then, as the impact of increment of low production, the forest area decreased drastically and, thus led to the reduced number of log production. But the next year showed that the log production was increasing and the forest area kept decreasing up till the year 1998. From this, it can be concluded that, the higher the log production the lower the forest area.

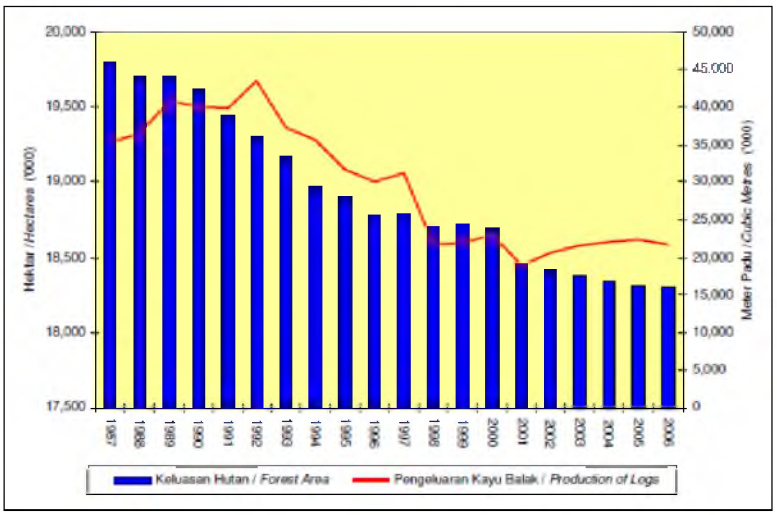

Figure 1.1: Principal Statistics of Forestry and Logging, 1987 - 2006, Malaysia

(Source: Malaysia Forestry Department)

Although the action for forest gain has been done to overcome the deforestation problem, it is not enough to cover back the loss of the forest. Malaysian Forest Department obtains forest resource information from forest inventories. Forest inventories in Malaysia consist of Pre-Felling Inventories, Continuous Forest Inventories, and National Forest Inventory (FAO, 2002). Most of the research on forest gain and loss has been done globally, which does not include the forest cover change or change detection of Malaysia forest from the year of 1990 to 2010 using satellite imagery (FAO 2010). In fact, forest cover change with the help of remote sensing data will provide high accuracy of information for peoples' awareness and gives real time information. Thus, this study focuses specifically on the forest cover in Peninsular Malaysia using a multi temporal image of Landsat satellite data.

In order to detect forest from Landsat data, CLASlite system is very useful. It is an automated system that can provide services of spectral signal processing and

advanced atmospheric correction (Asner, 2009). The Forest statistical system consumes a lot of time, thus it brings major problem for the data collection purposes. (FAO, 2002). This is because the conventional way of forest cover detection is still being used. However, recently the forestry department used satellite image to detect the forest cover, but this was not perfectly done (FAO, 2002). It is because the skill and knowledge about satellite image and system is still at a low level. In terms of system, there are three related systems, which are Geographic Information System (GIS), Management Information System (MIS), and a remote sensing system. These systems were developed by the forestry department to handle the forest cover data (FAO, 2002).

Unfortunately, in 1999 the project was terminated. Hence, the termination brought about incompletion and uninstallation of the GIS and MIS Systems integration (FAO, 2002). For knowledge limitation, this is related to definitions of terms and classifications. Although, they knew about the definition of certain features of land cover, but the skill and knowledge of their visual interpretation to classify them is at the low level (FAO, 2002). So, with the use of knowledge in remote sensing image and remote sensing tools like CLASlite software, it will increase the speed of data acquisition and forest monitoring. Accurate detection of forest change area is also possible, thus the determination of forest loss and gain can be determined. Malaysia has a very wide area of forest cover, that contains a lot of important and valuable natural resources. A critical issue that relate to forestry, are deforestation, sustainable forest management, timber certificate in trading and management of the forest ecosystem. These issues does not only apply to Malaysia but worldwide (Razak, et al, 2005). So, it is important to preserve the forest cover and understand the reason for the depletion of the area. From the rates of depletion, remedial measures can be taken in order to restore the forest and provide the essential key for any terrain forest assessment (Sakthivel et al, 2009). This study will help to determine the forest loss area, which can be used for preservation and conservation practice planning and management. Hence, forest cover

change study in Peninsular Malaysia must be carried out using satellite remote sensing data because the data can be easily obtained and at a low cost.

1.3 Aim and Objectives

The aim of this study is to provide statistics on forest cover changes in Malaysia from 1990 to 2010 using remote sensing data.

The following objectives are formulated to achieve the aim of the study

a) To classify forested areas in Malaysia using CLASlite program, Support Vector Machine (SVM), and Maximum Likelihood Classifier (MLC) algorithm.

b) To detect forest cover change in Peninsular Malaysia over a period of 20 years.

c) To analyse the deforestation and degradation of forest on a selected regions in Peninsular Malaysia

1.4 Scope of Study

Forest coverage change was performed over Peninsular Malaysia using Landsat TM and ETM+ images. In addition to Landsat, the ALOS Palsar radar image was also used to discriminate palm oil area from forested areas. A lot of development and log production to generate income occurred since 1990. Therefore, the period of time from 1990 to 2010 is an important period to study the changes of forest cover with the available data from Landsat . However, due to the heavy cloud cover only two sub-regions with less cloud cover were selected (Kuala Lumpur and Iskandar Malaysia) to analyse the deforestation and degradation of forest cover between 1990 and 2010.

Landsat was launched from the year 1972 with multispectral sensors. Thus, in order to study the forest cover changes in Malaysia for the year 1990 to 2010, Landsat image is a very suitable to be used. The Landsat TM and ETM+ sensors continously store images that they capture since they were operating. Besides, United State Geological Survey (USGS) website provide a service where Landsat satellite data can be downloaded for free (http://glovis.usgs.gov/). But, because Landsat is an optical satellite, it contains cloud cover in the image. The location of Peninsular Malaysia itself, which always under the cloud cover makes it quite difficult to get cloud free image. ALOS Palsar images were used for forest detection in Peninsular Malaysia. As ALOS Palsar is a radar data, it contains cloud free images. Furthermore, ALOS Palsar can separate forest and non forest area using the backscatter value that it gains (Shimada M.et al, 2014). Thus the finding of forest cover from ALOS Palsar was compared with the Landsat forest cover detection. ALOS Palsar data was only used for forest cover detection in this study because, ALOS Palsar was not develop during 1990, so forest change detection could not be carried out using ALOS Palsar data.

This study used a CLASlite program to classify a forest area from Landsat data. CLASlite program produces fractional cover maps. Fractional cover maps consist of three categories, the first one is live and dead vegetation which at the end will be extracted into forest and non forest cover. While the other two are bare soils and other substrates. Then automated decision tree is carried out by CLASlite in order to produce disturbance and deforestation map. This software, has been widely used to study the deforestation and forest degradation scenarios of tropical forest sites worldwide (Asner, 2009). Besides that, Support Vector Machine Algorithm (SVM) and Maximum Likelihood Classifier (MLC) were also used to detect and classify forest cover in Peninsular Malaysia as a cross reference to CLASlite product. The results were validated using forest cover statistics obtained from the Forestry Department of Peninsular Malaysia and landuse maps obtained from the Department of Agriculture, Peninsular Malaysia. Sabah and Sarawak were not included in this study because of the difficulty in obtaining forest cover data from Sabah and Sarawak forest department

1.5 Significance of Study

The study of forest cover change in Peninsular Malaysia can contribute to the dataset for the Environment Performance Index (EPI) for forest field. EPI calculates nine issues in which each of it fit under one of two overarching objectives which are Environmental Health and Ecosystem Vitality. One of the nine issues that are calculated is forest. Forest was studied under forest cover change (http://epi.yale.edu/). Malaysian forest was at the rank of 129 out of 137 countries for the forest environmental index. Thus, studying forest cover change will contribute to a better forest cover management in Malaysia.

The study on forest changes aims mainly at helping in the forest monitoring process where, the number of forest gain and loss can be predicted and will help Malaysian government to preserve forest from loss. So it is very beneficial especially to the Forestry Department to have accurate data of forest change. On the other hand, the results of forest cover change will help Malaysian Government to prepare and take brilliant action in preserving the forests in a better way by which they can estimate the quantity of the replantation needed to be done in order to cover the amount of forest loss.

CLASlite program was used in this study because it automatically classifies the forest area from Peninsular Malaysia. CLASlite can give a better result in terms of forest detection and change, especially for tropical forest within a short period of time using remote sensing data. The compatibility of this software allows the use of Landsat data from the year 1990. The other studies that have been done for forest cover change were not located in Peninsular Malaysia and the CLASlite software was not used.

1.6 Study Area

The area of study is the Peninsular Malaysia area. The spatial data that was used in this study are the remote sensing images covering Peninsular Malaysia area. Malaysia is one of the developing countries in the world which are in the category of humid tropical climate. Malaysias' average daily temperature is about 21-32 degree Celsius. It is also one of the country that has a high rainfall rate, which is more than 2540 mm p.a with about 85 percent average humidity (FAO, 2006). Peninsular Malaysia annual rainfall occurs for a long period of time, and the mean recorded is more than 1600 mm

(Dale, 1959). Rainfall affected at the northern part from November to March and the southern part from June to August with monsoons that bring heavy rainfall. Less rain is experienced from April until May and from September until October, because the change of monsoonal winds (FAO, 2006).

Peninsular Malaysia is covered by forest and swamps for about four-fifths of the region, agricultural zone located in the inland belt. As it is a suitable site for plantations, palm oil and rubber were planted widely in this area (FAO, 2006). Forest replantation was carried out in Malaysia in order to overcome the depletion possibility of timber resources (Malik et. al, 2013). The major contributor to the exports of the country is the timber sector. National Timber Industry Policy stated that over the last 10 years, there were increasing trend in timber production except for 2001. The production declined to RM14 billion from RM17.7 billion from the previous year. The global economic recession was mainly the cause of the declination for the year 2001 (NATIP, 2009).

For agricultural activities, palm oil and rubber become the main plantation efforts. In 2007, Malaysia recorded 15.8 Mt of crude palm oil production. With this successful achievement, Malaysia became the world largest palm oil exporter (Malik et. al, 2013). The Malaysian tropical rain forest is also the most suitable climate for other agricultural enterprises like mango and sugar cane. Cocoa plantation needs partial shade and richer soils, while the coconut is located along the coastal alluvium area in the Peninsular Malaysia area (FAO, 2006). This, shows that Malaysia has a lot of agricultural activities that have been carried out and brings a lot of profit to the economy.

1.7 Organisation of Chapters

There are five chapters in this study, which are Introduction, Literature Review, Methodology, Result and Discussion, and Conclusion. The first chapter defines issues related to the forest cover change, the research problems and formulates the specific objectives of the project. While in chapter 2, presents a change detection method using remote sensing. The methods used to achieve the objectives of the study are detailed out in chapter 3. The main results of the study are discussed in the chapter 4. The last chapter concludes the study and provides recommendation for future works.

REFERENCES

Abd El-Kawya O.R, Rod J.K, Ismail H.A., and Suliman A.S. (2011). Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data. Applied Geography 31 (2011) 483-494.

Abdul Razak M.A, H. Norini2 and B. Krishnapillay. (2005). Forestry Research and Education in Malaysia. Forest Science and Technology Vol. 1, No. 2, pp. 176-184

Ahmad A and Quegan. (2012). Analysis of Maximum Likelihood Classification on Multispectral Data. Applied Mathematical Sciences, Vol. 6, 2012, no. 129, 6425 – 6436

Aghababaeea H , J. Aminia, Y.C. Tzengb (2012) Improving change detection methods of SAR images using fractals. Scientia Iranica, Transactions A: Civil Engineering 20 15–22

Alnutt, T. F., Asner, G. P., Golden, C. D. and Powell, G. V. N. (2013) Mapping recent deforestation and forest disturbance in northeastern Madagascar. Tropical Conservation Science Vol. 6(1):1-15.

Anders H. Siren and Eduardo S. Brondizio. (2009). Detecting subtle land use change in tropical forests. Applied Geography 29 (2009) 201–211

Arnon S, Sadot D. and Kopeika N.S (1994) Analysis of Optical Pulse Distortion Through Clouds for Satellite to Earth Adaptive Optical Communication.Journal of Modern Optics, 41:8, 1591-1605

Asner G.P, David E. Knapp, Aravindh Balaji, and Guayana Páez-Acosta.(2009). Automated mapping of tropical deforestation and forest degradation: CLASlite. Journal of Applied Remote Sensing, Vol. 3, 033543

Berberoglu S. and Akin A. (2009). Assessing different remote sensing techniques to detect land use/cover changes in the eastern Mediterranean .International Journal of Applied Earth Observation and Geoinformation 11 p. 46–53

Borrelli P., Luis Alfonso Sandia Rondón and Brigitta Schütt. (2013). The use of Landsat imagery to assess large-scale forest cover changes in space and time, minimizing false-positive changes. Applied Geography 41 147e157

Brown J. C. , Jepson W. E,. Kastens J. H,. Wardlow B. D,. Lomas J. M and. Price K. P. (2007). Multitemporal, Moderate-Spatial-Resolution Remote Sensing of Modern Agricultural Production and Land Modification in the Brazilian Amazon. GIScience & Remote Sensing, 2007, 44, No. 2, p. 117–148 .

CLASlite (2013).CLASlite Forest Monitoring Technology version 3.1 user guide. Carnegie Institution For Science Department Of Global Ecology 260 Panama Street Stanford, Ca 94305 Usa.

Coppin P. R And Marvin E. B (1996). Change Detection in Forest Ecosystems with Remote Sensing Digital Imagery. Remote Sensing Reviews 13:207-234

Dale, W.L. (1959). The rainfall of Malaya - Part I. Journal of Tropical Geography. 13, 30–32

Daniel R. Unger, David L. Kulhavy and I-Kuai Hung. (2013). Validating the geometric accuracy of high spatial resolution multispectral satellite data. GIScience & Remote Sensing, 2013Vol. 50, No. 3, 271–280

Dong J, Xiangming Xiao, Sage Sheldon, Chandrashekhar Biradar, Geli Zhang1, Nguyen Dinh, Duong, Manzul Hazarika, Ketut Wikantika, Wataru Takeuhci, Berrien Moore.(2014). A 50-m Forest Cover Map in Southeast Asia from ALOS/ PALSAR Assessment. PLOS one Volume 9 ,Issue 1 , e85801

Duan K.B. and Keerthi S. S.(2005) Which Is the Best Multiclass SVM Method?

An Empirical Study. Springer-Verlag Berlin Heidelberg.MCS 2005, LNCS 3541, pp. 278–285

FAO. (2012).State of the World's Forests 2012. Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy. (page 9 – 19)

FAO. (2002) An overview of forest products statistics in South and Southeast Asia. Ec-Fao Partnership Programme (2000-2002) Tropical Forestry Budget Line B7-6201/1B/98/0531 PROJECT GCP/RAS/173/EC in collaboration with Forestry Department Headquarters, Rome.

FAO. (2000). Global Forest Resources Assessment 2000 Report. Forestry Department

FAO. (2002). Global Forest Resources Assessment 2000 Report. Forestry Department

FAO. (2010). Global Forest Resources Assessment 2010 Main Report. FAO Forestry Paper No.163. Rome.

FAO. (2013). Global Forest Resources Assessment 2000 Report. Forestry Department

FDPM. (2008) Forest Inventory In Malaysia with special reference to Peninsular Malaysia.2008.

FDPM. (2000) Forestry Department Peninsular Malaysia. 2000. Annual Report

FDPM .Forestry Department Peninsular Malaysia. 2000. Forestry Statistics Peninsular Malaysia.

Fernando Sedano, Pieter Kempeneers, Peter Strobl, Jan Kucera, Peter Vogt, Lucia Seebach, and Jesús San-Miguel-Ayanz. (2011). A cloud mask methodology for high resolution remote sensing data combining information from high and medium resolution optical sensors. ISPRS Journal of Photogrammetry and Remote Sensing 66 (2011) p588–596

Global Forest Resources Assessment 2010 Country Report Malaysia.2010

Hamdan O, Khali Aziz H, and Abd Rahman K (2011). Remotely Sensed L-Band Sar Data For Tropical Forest Biomass Estimation. Journal of Tropical Forest Science 23(3): 318–327

Hansen M.C, Potapov P. V., Moore 1 R., M. Hancher,S. A. Turubanova,. Tyukavina,D. Thau, V. Stehman,S. J. Goetz,T. R. Loveland, Kommareddy,. Egorov, L. Chini, O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 342, 850

Hayes and Sader (2001). Comparison of ChangeDetection Techniques for Monitorin Tropical Forest Clearing and Vegetation Regrowth in a Time Series. Photogrametric Enginering and remote Sensing. Vol. 67. No. 9, September 2001. (pp 1067- 1075)

Hossein Aghababaee, Jalal Amini, and Yu-Chang Tzeng.(2013). Improving change detection methods of SAR images using fractals. Scientia Iranica, Transactions A: Civil Engineering 20 p15–22

Huang C., Kuan Song, Sunghee Kim, John R.G. Townshend , Paul Davis, Jeffrey G. Masek , and Samuel N. Goward. (2008) Use of a dark object concept and support

vector machines to automate forest cover change analysis. Remote Sensing of Environment 112 (2008) 970–985.

Huang X., and Mark A. Friedl.(2014). Distance metric-based forest cover change detection using MODIS time series. International Journal of Applied Earth Observation and Geoinformation 29 p78–92.

Jari Varjo and Sten Folving. (1997). Monitoring of forest changes using unsupervised methods: A case study from boreal forest on mineral soils .Scandinavian Journal of Forest Research 12: 362-369

Jennings S, Nussbaum R, Judd N and Evans T.(2003). The High Conservation Value Forest Toolkit. Edition 1. WWF and IKEA Co-operation on Forest Projects

Koch B.(2011). Remote Sensing supporting national forest inventories NFA. Knowledge Reference for National Forest Assessments. Knowledge Reference for National Forest Assessments. FAO.

Lu. D , P. Mausel , E. Brondízio and E.Moran.(2004) Change detection techniques. Int. J. Remote Sensing.Vol. 25, No. 12, 2365–2407

Memon P.A. (2000) Devolution of environmental regulation: environmental impact assessment in Malaysia. Impact Assessment and Project Appraisal, volume 18, number 4, December 2000, pages 283–293

Minho Kim, Marguerite Madden, and Timothy A. Warner. (2009). Forest Type Mapping using Object specific Texture Measures from Multispectral Ikonos Imagery: Segmentation Quality and Image Classification Issues. Photogrammetric Engineering & Remote Sensing Vol. 75, No. 7, pp. 819–829

MTIB. (2012) Malaysian Timber Statistics 2009-2011. Malaysian Timber Industry Board, Kuala Lumpur

Myeong S., David J. Nowak , and Michael J. Duggin .(2005) Temporal analysis of urban forest carbon storage using remote sensing. Remote Sensing of Environment 101 277 – 282

NATIP. National Timber Industry Policy 2009-2020. FIRST EDITION 2009

NRE.(2014) Master List of Protected Areas in Malaysia. Ministry of Natural Resources and the Environment (NRE).

Priyadarshi Upadhyay , S.K. Ghosha, and Anil Kumar. (2013) Moist deciduous forest identification using temporal MODIS data — A comparative study using fuzzy based classifiers. Ecological Informatics 18 p117–130

Malik A.R.A, Hamzah K. A, and Joseph K.T. (2013). Land use change in Malaysia. Reports from the Technical Panels of the 2nd Greenhouse Gas

Working Group of the Roundtable on Sustainable Palm Oil (RSPO p 113- 30

Ravinder Virk and Doug King. (2006). Comparison of Techniques for Forest Change Mapping Using Landsat Data in Karnataka, India. Geocarto International, Vol. 21, No. 4.

Sakthivel R., M. Manivel, N. Jawahar raj, V. Pugalanthi, N. Ravichandran and Vijay D. Anand.(2010). Remote sensing and GIS based forest cover change detection study in Kalrayan hills, Tamil Nadu. Journal of Environmental Biology

Sedano F, Pieter Kempeneers, Jesús San Miguel, Peter Strobl, and Peter Vogt. (2013). Towards a pan-European burnt scar mapping methodology based on single date medium resolution optical remote sensing data. International Journal of Applied Earth Observation and Geoinformation 20 (2013) p52–59

Shannon L.S. and Rick L. Lawrence.(2012). Analyzing Change in Yellowstone's Terrestrial Emittance with Landsat Imagery. GIScience & Remote Sensing, 2012, 49, No. 3, p. 317–345.

Shimada M., Itoh T., Motooka T., Watanabe M, Shiraishi T, Thapa R., and Lucas R.(2014).Newglobal forest/non-forest maps fromALOS PALSAR data (2007–2010). Remote Sensing of Environment 155 pp13–31

Singh A. (1989). Digital change detection techniques using remotely sensed data. International Journal of Remote Sensing Vol.10, No.6, pp.989-1003.

Sugumaran R.(2001) Forest Land Cover Classification Using Statistical and Artificial

Neural Network Approaches Applied to IRS LISS - III Sensor. Geocarto International, Vol. 16, No. 2, June 2001

Toshihiro S., Nhan Van Nguyen , Akihiko Kotera , Hiroyuki Ohno, Naoki Ishitsuka , and Masayuki Yokozawa. (2007). Detecting temporal changes in the extent of annual flooding within the Cambodia and the Vietnamese Mekong Delta from

MODIS time-series imagery. Remote Sensing of Environment 109 (2007) 295–313

Townshenda J.R, Jeffrey G. M., Huanga C, Vermotec E.F, Gaod F, Channana S, Sextona J.O, Fenga M, Narasimhana R, Kima D, Songc K, Songa D, Songa X, Noojipadya P, Tanb B, Hansen M.C, Lic M, and Wolfe R.E.(2012). Global characterization and monitoring of forest cover using Landsat data: opportunities and challenges. International Journal of Digital Earth, 2012, 1-25

United Nations Environment Programme World Conservation.(UNEP). (2009). Global Ecological Forest Classification and Forest Protected Area Gap Analysis .Institute of Forest and Environmental Policy (IFP). University of Freiburg

Valožić L and Cvitanović M. (2011). Mapping the Forest Change: Using Landsat Imagery in Forest Transition Analysis within the Medvednica Protected Area. Original scientific paper. Hrvatski Geografski Glasnik 73/1, 245 – 255

Vogt, P. Riitters, K.H. Iwanowski, M. Estreguil, C. Kozak, J. and Soille, P. (2007). Mapping landscape corridors. Ecological Indicators, 7, 481-488

Wulder M.A(1998). Optical remote-sensing techniques for the assessment of forest inventory and biophysical parameters. Progress in Physical Geography 22,4 (1998) pp. 449±476

Xie Y, Sha Z, and Mei Y(2008). Remote sensing imagery in vegetation mapping: a review. Journal of Plant Ecology Volume 1, Number 1, Pages 9–23 March 2008

Websites

1. claslite.carnegiescience.edu (2 January 2014)

2. www.iucn.org (4 January 2014)

3. http://glovis.usgs.gov (4 January 2014)